International Journal of Scientific Research in Science and Technology
Print ISSN: 2395-6011 | Online ISSN: 2395-602X (www.ijsrst.com)
doi : https://doi.org/10.32628/IJSRST

Process Hazard Analysis of Process Industries

Rutik Hemanbhai Majethiya[1], Dr. Ashish Unnarkat[2], Mr. Yogendra Dave[3]

[1]Dept. of Chemical Engineering, Pandit Deendayal Energy University, Gandhinagar, Gujarat, India

[2]Assistant Professor, Dept. of Chemical Engineering, Pandit Deendayal Energy University, Gandhinagar, Gujarat, India

[3]HOD - Industrial Safety Services Division, Zeppelin Systems India Pvt. Ltd., Vadodara, Gujarat, India

Article Info
Volume 9, Issue 5
Page Number : 676-691

Publication Issue
September-October-2022

Article History
Accepted : 01 Sep 2022
Published : 12 Sep 2022

ABSTRACT

Process Hazard Analysis (PHA) and Risk Assessment Techniques are the key factors in industrial safety. The Process safety management permits the utilization of various analysis techniques and elimination or mitigation of the various hazards in process industries. Hazard Identification (HAZID) helps in defining all possible hazardous events, through which one can be prepared for probable solutions beforehand. Hazard and Operability (HAZOP) study is the main technique for analyzing various hazards that can occur in industry. Of various types of HAZOP methodology, deviation by deviation methodology will be adopted for this particular thesis. The following research article is intended to conduct the HAZOP study of the chemical plants and present the outcomes. QRA is a quantitative risk assessment model widely used worldwide for risk assessment methods to estimate and then score numerical estimates of the level of risk associated with a specific activity or set of activities.

Keywords : PHA,HAZID ,HAZOP, QRA, Risk Management, Process Safety Management.

I. INTRODUCTION

HAZARDIDENTIFICATION (HAZID)

Hazard identification (HAZID) is the system of figuring out risks, which is the vital first step of a chance evaluation. HAZID facilitates to gain a listing of risks for next assessment the use of different chance evaluation techniques. This is on occasion called failure case selection. It additionally facilitates to carry out a qualitative assessment of the importance of the risks and the measures for lowering the dangers from them. This is on occasion called risk evaluation [1, 6].

PURPOSE

The objectives of the HAZID technique are to discover the main risks, to verify the effectiveness of the protective measures adopted and, if necessary, to extend the protective measures in order to achieve a tolerable residual probability. In accordance with aim to prevent major accidents involving dangerous substances and limiting their consequences for people and the environment, with a view to ensuring a high level of protection throughout the community in a coherent and effective manner, apart from system protection concepts for completely new systems, additional protection concepts for existing operating sites must be checked [2]. The operating control receives an up-to-date picture of the existing risks and their possible effects.

With the HAZID assessment approach, due to the technology-based form, the number one system risks, but also non-systemic risks and their possible escalations can be identified. Employees can be made aware of the applicable risks with regard to their work area. .At the same time, the results can be used as a tool to collect the desired community information. The system planner takes into account the effects of the evaluation to improve the protection concepts for newly constructed systems.

The perks of HAZID are:

1. Review the process at an early stage with a view to ensuring that the process design accounts for credible hazardous scenarios
2. Review safeguards included in the design of the process designed to mitigate the relevant risk for the identified hazardous scenarios.

In order to conduct a successful HAZID workshop, it is important to involve a multi-disciplinary team familiar with the process and its operation. The study should be led by an experienced chairman; with a scribe to record all identified hazardous scenarios, likely consequences, safeguards and actions [5, 7]. The effectiveness of the HAZID relies heavily on the experience of the workshop team to ensure that relevant foreseeable scenarios are captured. The high-level nature of a HAZID is suitable to review the design at an early stage without requiring in-depth knowledge of the operation.

II. METHODOLOGY

HAZID is likely to be one of the first formal HSE-related studies for any new project and is normally performed at the early design stage of a project. The major benefit of conducting a HAZID at this time is the early identification of high consequence hazards providing essential input to project development decisions before the design reaches its final stages. This will lead to safer and more cost- effective design options being adopted with a minimum cost of change penalty [7].

It is a flexible risk analysis technique that can be used at any time in the lifecycle of a plant, from early project life to decommissioning. For example, HAZID analyses are often used for Management of Change where modifications, upgrades, or re-design of existing facilities are carried out. During the random identification phase,

standards for hazard identification could be established and feasible risks and injuries could be reviewed. For this purpose, the plant could be divided into numerous sections. In addition, the diagnosed risks could be divided into significant and non- significant risks (See Figure 1.1).

Hierarchy of Risk

It is of the utmost importance that risks that are not considered material are actually documented to demonstrate that the activities concerned can be properly disregarded [10]. This failure case choice could be achieved via way of means of producing test lists, twist of fate and failure statistics, chance and operability studies (HAZOPs) or via way of means of assessment with targeted research and revel infrom preceding projects [8]. For every of the regions which comprise poisonous or flammable inventories, the info are compiled, additionally inclusive of probable sources of ignition. Before HAZID, the plant is split into severaloperable sections

The purpose of the chance state of affairs identity is the grouping of comparable results of various risks. Based at the information compiled in the HAZID stage, the primary chance situations may be diagnosed [9]. Typically, occasional situations consist of launch, fire, explosion, and propagation situations. Example: For the Small Launch Opportunity (or Initial Event), the appropriate opportunitysituations are: BLEVE (Boiling Liquid Expanding Vapour Explosion), fireball escalation to huge launch fire, jet fire- no escalation and unignited launch [3].

The HAZID study team should be neither too big nor too small. Ideally, the test is carried out by a team of three to five people plus a moderator and a secretary. Ideally the analysis is completed by a team of three to five people, a facilitator and a secretary. The team constitutes of a layout engineer for the respective facility, a plant engineer, a process engineer and a scribe [2, 4]. Then, guidewords must be applied to the processes and check for their applicability in that area.

List of Guide words for HAZID:

Guideword	Considerations				
Hazardous Substances	Flammability	Toxicity	Reactivity	Corrosivity	Contamination
Process Upsets	Flow	Temperature	Pressure	Chemistry	Composition
Environment	Air	Water	Spillage	Waste	
Equipment Malfunction	Vessels	Ancillary Equipment	Valves	Control Instrumentation	Safety Devices
Integrity Failures	Process Caused	Material Caused	Structural		
Utility Failures	Air	Steam	Nitrogen	Vacuum	Ventilation
Human Factors	Task Error	Information Issues	Timing Issues	Wrong Action	Poor HMI
Sampling / Analysis	Missed Sample	No / Incorrect Test Result	Sampling Hazard	Inaccurate Test	
External Effects	Crane ops	Vehicles	Offsite Accidents	Sabotage	Fire
Natural Hazards	Wind	Flood	Heat	Cold	Earthquake
Emergency Ops	Fire	Explosion	Toxic Release	Environmental Release	Offsite

For the HAZID workshop, the operation is divided into manageable, logical sections (systems, units or nodes). Section limits are often identified by a significant change in the process conditions, a change in location or in material phase and composition [9]. Divisions of a complex facility, for example, can be processing units, but less comprehensive facilities could also be sub-divided into functional groups. Section limits may be diagnosed

as an instance wherein there may be a huge change inside the system specifications or a change in segment and composition. Sections can also be diagnosed in a manner that one phase carries gas and the other carries liquid.

HAZID Report Format:

Sr. No.	Plant Area /Activity	Cause	Type	Threat	Conseq-uences	Current Risk Ranking	Mitig-ation	Risk Ranking after Safeguards	No.	Recommen-dations

A HAZID study typically follows the sequence illustrated below:

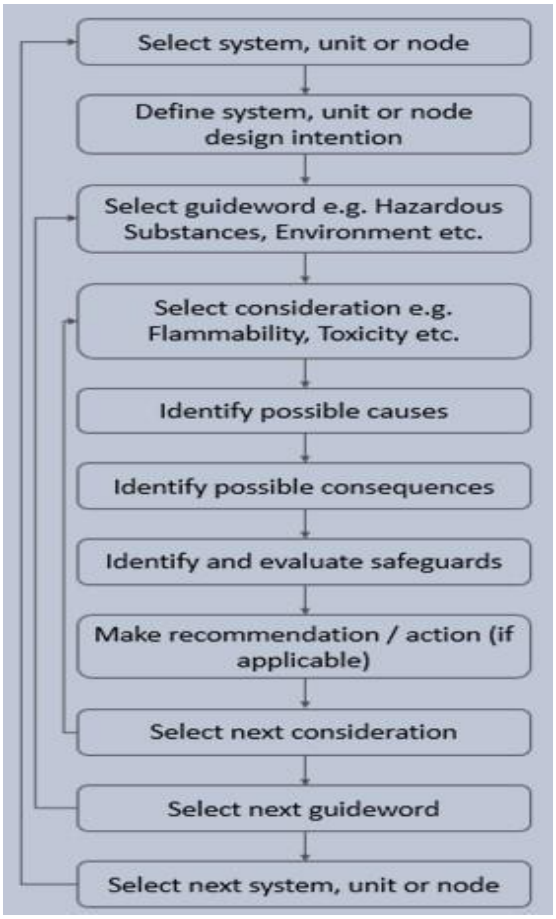

Figure 1.2 : Flow of HAZID Process

The sections are written inside the phase department report shown in table below. This preparatory details inclusive of the compilation of the P&ID sheets for every described unit in addition to the HAZID phase department report is commonly completed via way of means of the facilitator. Subsequent to the comments received, the organized files are open to all for constructive criticism and further feedback [5].

Risk Matrix

Severity	Consequences				Increasing Likelihood				
					A	B	C	D	E
	People	Assets	Environment	Reputation	Never heard of in the industry	Heard of in the industry	Has happened in the organization or more than once per year in the industry	Has happened at the location or more than once per year in the organization	Has happened more than once per year at the location
0	No injury or health effect	No damage	No effect (no or temporary impact - days)	No impact (local media, no significant concern)	L	L	L	L	L
1	Slight injury or health effect (first aid or medical treatment)	Slight damage	Slight effect (local scale, short term damage – weeks)	Slight impact (short term local concern)	L	L	L	L	L
2	Minor injury or health effect (restricted work case or LTI)	Minor damage	Minor effect (local scale, short term damage – months)	Minor impact (short term national mention)	L	L	L	M	M
3	Major injury or health effect (partial disability)	Moderate damage	Moderate effect (local scale, medium terms damage – years)	Moderate impact (medium term national concern)	L	L	M	M	H
4	< 3 fatalities, or permanent total disabilities	Major damage	Major effect (local scale, long term damage – decades)	Major impact (regional or persistent national concern)	L	M	M	High Risk (Formal Demonstration of ALARP required)	
5	> 3 fatalities	Massive damage / total loss	Massive effect (regional scale, permanent damage)	Massive impact (global concern and media coverage)	M	M	H	H	H

L	Low risk
M	Medium risk
H	High risk

Further analysis is required for both yellow and red area as those areas indicate significant hazards and ensure that the risk is ALARP.

DEMONSTRATION OF HAZID

PROBLEM STATEMENT

A refinery is planning for installation of Purified Terephthalic Acid (PTA) as an integrated PX-PT unit. The unit comprises of Paraxylene (PX)generation unit of 0.8 MMTPA and 1.2 MMTPA generation facility of PTA. Effluent Treatment Plant (ETP) including Wastewater treatment (WWT) plant, Effluent Treatment Plant (ETP) & disposal facilities are required for the proposed PX-PTA integrated complex at the refinery to treat wastewater effluents and other effluents from PX -PTA complex. The water management plan at PTA is being implemented which includes water conservation measures such as to reduce the net raw water requirement by way of

recycle/reuse of treated waste water to the maximum possible extent wherever it is feasible. One new ETP including WWT plant and ETP & disposal facilities are being considered for PX-PTA complex as the existing ETP at the refinery cannot be utilized for the same. Gaseous effluents were discharged to atmosphere after treatment. Hence those components are not covered in this specification [11].

Effluent generated from Purified Terephthalic Acid (PTA), Paraxylene (PX) and & offsite and utilities plant are to be collected, segregated and treated in ETP to meet applicable regulatory requirements before final disposal. RO based treatment is envisaged for final disposal. Rejects from RO plant to be transfer in sea.

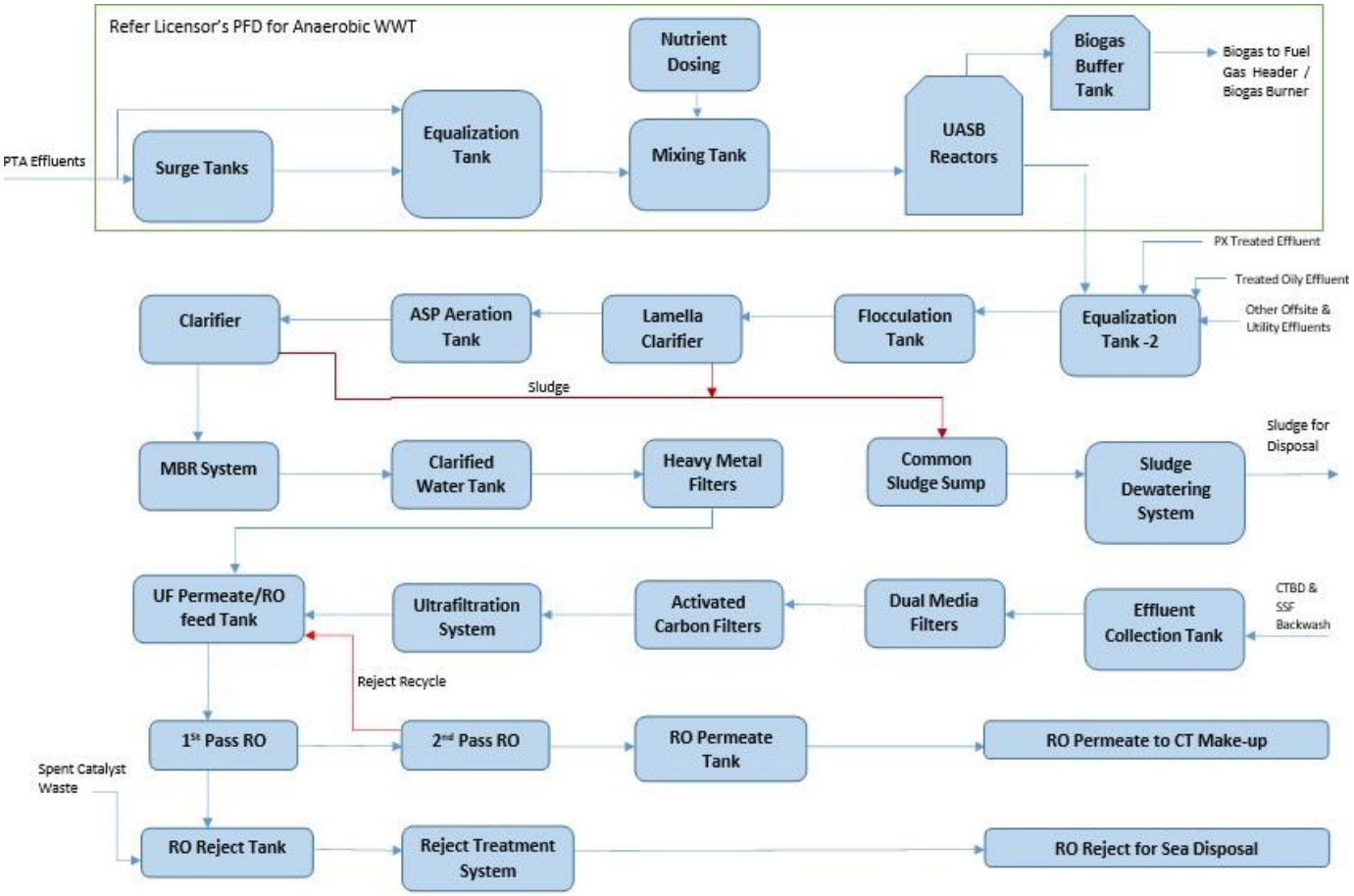

Figure 2.1 Treatment flow diagram for ETP

ABBREVIATIONS USED IN HAZID REPORT

AIC: ASHRAE India Chapter
DG: Diesel Generator
DMP: Disaster Management Plan
ECSB: External Circulation Sludge Bed
EVP: Emergency Evacuation Plan
HC: Hydrocarbon
HIRA: Hazard Identification and Risk Assessment
KOD: Knock Out Drums
LFL: Lower Flammability Limit
MIQA: Mechanical Integrity and Quality Assurance

MOC: Material of Construction
NA: Not Available / Not Applicable
NFPA: National Fire Protection Association
NFZ: No-Fly Zone
PA: Public Announcement
PPE: Personal Protective Equipment
PMC: Project Management Consultant
SMP: Safety Management Plan
SOP: Standard Operating Procedure
UFL: Upper Flammability Limit

III. HAZIDREPORT

HAZID Report

S.No	Plant Area/ Activity	Hazard Due to	Type of Hazard	Cause / Threat due to what failure &under what circumstances	Consequences (Immediate and escalating)	Current Risk Ranking			Existing Safe Guards/ Mitigation	After Safeguard Risk Ranking			No.	Recommendations/ Actions
External Hazards	Plant Area	Earthquake	Damageto structure	SeismicZone in between3and4 withzonefactor of 0.22 for refinery area	Potential damage plant which may resultininjury/ fatality Fireand explosion	5	B	H	Adequate safetymargins are kept by designers	2	B	M	R-1	Ensureon-siteand off-site EEP and DMP
		Thunderand Lightning	Fire and Explosion	Potentialhazard from lightning exists	Potential damagetoplant Fireand Explosion	4	C	H	Lightning arrestorsare provided	2	C	M	R-2	Recommended to conduct lightning arrestorsurveyasper IS/IEC62305
													R-3	Necessarydesign provision and operating procedure to be ensured and specifiedbyPMCas protection from

														lightning
		LandSlide	Noforeseen hazard											
		Heavy Rainfall	Flooding of water in plant area leading to submergenceof electrical equipment	Improper hydraulics design	Unit will submerge damaging electrical equipment and untreatedwater Discharge	4	C	H	Plant is designed considering maximumrain load	2	C	M	R-4	Ensure that no reverseflowtakes place from sea to plant
									Emergency\ shutdown procedures for safeguarding the plant from naturaldisaster like cyclone, floodsarein place					
		Aircraft	Refinery is declared as NFZand hence norisk											
		PA (Public Announcement) system	Communication problem	Notprovided and/ or not working	Communication gap during emergency can lead to disoperationand Chaos	4	A	M	NA	4	A	M	R-5	Recommended to providePAsystem with two way communication

		Emergency Siren	Communication Problem	Notprovided and/ or not working	Communication gap during emergency can lead to disoperation and Chaos	4	A	M	NA	4	A	M	R-6	Considerproviding emergency siren systemfordifferent situations with predefined type as wellasclearpitch.
		MOC	Highcorrosion & erosion	Improper selection of MOCoruseof wrong ratio of civilmaterial	Damageto equipment leading to disastrous situation	4	A	M	RightMOCis selected by designers taking into consideration suitable allowancesas per standard codes	1	A	L	R-7	Ensureregular inspection and monitoringofallthe equipment
		BlackOut(No service power or DG power available)	Process upset andnovisibility	Failure of powersource	Operationupset and movement restriction. safe escape will not bepossiblein emergency	3	C	M	Rechargeable torches are provided inthe control room DGisavailable	2	C	M	R-6	Considerproviding emergency siren systemfordifferent situations with predefinedtypeas wellasclearpitch.
													R-8	Develop anSOPfor

S.No	Plant Area/ Activity	Hazarddueto	Typeof Hazard	Cause / Threat due to what failure &underwhat circumstances	Consequences (Immediate andescalating)	Current Risk Ranking	ExistingSafe Guards/ Mitigation	After Safeguard Risk Ranking	No.	Recommendations/ Actions

														testingDGatregular intervals and ensure auto-starttakesplace in specified time. Also provide restart proceduresforheavy equipments.
		SafetyShower/ Eye Wash	HealthHazard	Facility not providedandor not working	Notreatmentin case worker needs safety shower or eye washincase of anyunforeseen Incident	3	C	M	Safety showerareprovidedat specific locations	1	C	L	R-9	Ensure24×7potable water supply from overhead tank
		SOP/SMP	Disoperation and wrong maintenance	SOP not properlymade and or not followed	Equipment damageandor injury to the worker	3	C	M	SOP will be prepared, trainingwillbe providedbefore commissioningofthe plant	1	C	L	R- 10	Provide proper SOP/SMP after identifying active hazards through structuralHIRAwith adequatefacilityand PPE'stobeused
		Ventilation system	Suffocationand toxic, flammable gases accumulation	HVAC either notprovidedor not working in close building	Healthhazard due to less oxygenandor more carbon Dioxide	3	C	M	Exhaust fans areprovidedin each buildings	1	C	L	R- 11	Conduct ventilation survey as per AIC andprovideadequate exhaust system

Material Specific	Raw effluent (up to ECSB Reactor)	Effluentwater	Health, Environmental andequipment hazard	Structural or Mechanical failure and leakages, Overflow or manualerrorof draining	High odour of H2S,CH4, NH3 and other gases leadingtohealth hazard to workers	3	C	M	H2S and CH4 detectors are providedwith alarmswithin vulnerable vicinity	2	C	M	R- 12	Allworkersshould be trained for precaution to be takentoavoidsuch scenarios
														Periodichealthcheck of workers prone to such hazards should bedone
	Biogas burner	Fuel gas to burnerfromgas pipeline	Fire	Mechanical failureduetocorrosionand gasketfailure	Fire and explosion leadingtoinjury to the people, damage to property and environment	4	C	H	Suitable firefightingfacilities are providedas per NFPA guidelines	2	C	M		
	RO	HighTDSin RO reject	Adverseeffect onaquaticlife	Inefficient operationof RO	TDSofreject will increase	2	C	M	Onlineanalyser is provided at permeate line with interlock	1	C	L		

									to shut down membrane					
	Chemical dosing area	Polyelectrolyte (infinepowder form)	Environment and health hazard	Manual handling of polyelectrolyte and worker comes in contact while working	Adverse effect on the worker on respiratory system	2	C	M		2	C	M	R- 13	Recommended to ensure all safety precaution as per the guidelinesmentioned instandardMSDSof selected polyelectrolyte
	FeCl3/ H3PO4 / NaOCl/ HCl/ H2O2/ Ammonia Solution/ Caustic Lye	Healthhazard		Mechanical failure/Human error	Spillage of chemical around tank leading to health hazard	2	C	M		2	C	M	R- 14	Recommended to ensure Dyke is providedwithAcid& Alkali proof lining of 110% capacity with proper slope of dyke leading to dyke pit
													R- 15	Recommended to provide flange guard oneachflangesofthe pipeline passing throughworkingarea
	SlopOil handling	SlopOil	Humaninjury	Mechanical failure/	Fallhazardsand injury to	2	C	M		2	C	M	R-16	RecommendedtohaveproperMIQA

S.No	Plant Area/ Activity	Hazarddueto	Typeof Hazard	Cause / Threat due to what failure &under what circumstances	Consequences (Immediate andescalating)	Current Risk Ranking	Existing Safe Guards/ Mitigation	After Safeguard Risk Ranking	No.	Recommendations/ Actions

														testingDGatregular intervals and ensure auto-starttakesplace in specified time. Also provide restart proceduresforheavy equipments.
		SafetyShower/ Eye Wash	HealthHazard	Facility not provided andor not working	Notreatmenti n case worker needs safety shower or eye washincase of anyunforesee n Incident	3	C	M	Safety shower areprovidedat specific locations	1	C	L	R-9	Ensure24×7potable water supply from overhead tank
		SOP/SMP	Disoperation and wrong maintenance	SOP not properly made and or not followed	Equipment damageandor injury to the worker	3	C	M	SOP will be prepared, training willbe provided before commissioning ofthepla nt	1	C	L	R- 10	Provide proper SOP/SMP after identifying active hazards through structuralHIRA with adequatefacility and PPE'stobeused
		Ventilation system	Suffocationand toxic, flammable gases accumulation	HVAC either notprovidedor not working in close building	Healthhazard due to less oxygenandor more carbon Dioxide	3	C	M	Exhaust fans areprovidedin each buildings	1	C	L	R- 11	Conduct ventilation survey as per AIC andprovideadequate exhaust system
Material Specific	Raw effluent (up to ECSB Reactor)	Effluent water	Health, Environmental andequipment hazard	Structural or Mechanical failure and leakages, Overflow or	High odour of H2S,CH4, NH3 and other gases leadingtohealth hazard to workers	3	C	M	H2S and CH4 detectors are provided with alarmswithin vulnerab	2	C	M	R- 12	Allworkersshould be trained for precaution to be takentoavoidsuch scenarios

				manualerrorof draining					le vicinity					
														Periodichealthcheck of workers prone to such hazards should bedone
	Biogas burner	Fuel gas to burnerfromgas pipeline	Fire	Mechanical failureduetocorrosionand gasketfailure	Fire and explosion leadingtoinjury to the people, damage to propertyand environment	4	C	H	Suitable firefighting facilities are provided asper NFPA guidelines	2	C	M		
	RO	HighTDSin RO reject	Adverseeffect onaquaticlife	InefficientoperationofRO	TDSofreject will increase	2	C	M	Onlineanalyser is provided at permeate line with interlock to shut down membrane	1	C	L		
	Chemical dosing area	Polyelectrolyte (infinepowder form)	Environment and health hazard	Manual handling of polyelectrolyte and worker comes in contact while working	Adverseeffect on the worker on respiratory system	2	C	M		2	C	M	R- 13	Recommended to ensure all safety precaution as per the guidelinesmentioned instandardMSDSof selected polyelectrolyte

	FeCl3/ H3PO4/ NaOCl/ HCl/ H2O2/ Ammoni a Solution/ Caustic Lye	Healthh azard		Mechani cal failure/H uman error	Spillage of chemicalarou nd tank leading to health hazard	2	C	M		2	C	M	R- 14	Recommended to ensure Dyke is providedwithAc id& Alkali proof lining of 110% capacity with proper slope of dyke leading to dyke pit
													R- 15	Recommended to provide flange guard oneachflangesof the pipeline passing throughworking area
	SlopOil handling	SlopOil	Humaninj ury	Mechani cal failure/	Fallhazardsan d injury to	2	C	M		2	C	M	R- 16	Recommendedt o haveproperMIQ A

IV. REFERENCES

[1]. Kim, K.; Kang, H.; Kim, Y. Risk Assessment for Natural Gas Hydrate Carriers: A Hazard Identification (HAZID) Study. Energies 2015, 8 (4),3142–3164. https://doi.org/10.3390/en8043142

[2]. Hazard Identification and Analysis in Work Areas within the Manufacturing Sector through the HAZID Methodology. Process Safety and Environmental Protection 2021, 145,23–38. https://doi.org/10.1016/j.psep.2020.07.049.

[3]. Cameron, I.; Mannan, S.; Németh, E.; Park, S.; Pasman, H.; Rogers, W.; Seligmann, B. Process Hazard Analysis, Hazard Identification and Scenario Protection 2017, 110, 53–70. https://doi.org/10.1016/j.psep.2017.01.025.

[4]. Lucena, A. F. E.; Saffaro, F. A. Guidelines for Exploring Construction Sites in Virtual Reality Environments for Hazard Identification. International Journal of Occupational Safety and Ergonomics 2020, 1–10. https://doi.org/10.1080/10803548.2020.1728951.

[5]. Reyes-Calderón, A.; Pérez-Uribe, S.; Ramos-Delgado, A. G.; Ramalingam, S.; Oza, G.; Parra- Saldívar, R.; Ramirez-Mendoza, R. A.; Iqbal, H. M. N.; Sharma, A. Analytical and Regulatory Considerations to Mitigate Highly Hazardous Toxins from Environmental Matrices. Journal of Hazardous Materials 2022, 423, 127031. https://doi.org/10.1016/j.jhazmat.2021.127031.

[6]. Aven, T. Risk Assessment and Risk Management: Review of Recent Advances on Their Foundation. European Journal of Operational Research 2016, 253(1),1–13. https://doi.org/10.1016/j.ejor.2015.12.023.

[7]. Nguyen, H.-T.; Safder, U.; Kim, J.; Heo, S.; Yoo, C. An Adaptive Safety-Risk Mitigation Plan at Process-Level for Sustainable Production in Chemical Industries: An Integrated Fuzzy-HAZOP- Best-Worst Approach .Journal of Cleaner Production 2022, 339,130780.
[8]. https://doi.org/10.1016/j.jclepro.2022.130780.
[9]. Aqlan, F.; Mustafa Ali, E. Integrating Lean Principles and Fuzzy Bow-Tie Analysis for Risk Assessment in Chemical Industry. Journal of Loss Prevention in the Process Industries 2014, 29, 39–48. https://doi.org/10.1016/j.jlp.2014.01.006.
[10]. Khan, F. I.; Abbasi, S. A. Multivariate Hazard Identification and Ranking System. Process Safety Progress 1998, 17 (3), 157–170. https://doi.org/10.1002/prs.680170303.
[11]. Catino, C. A.; Ungar, L. H. Model-Based Approach to Automated Hazard Identification of Chemical Plants. AIChE Journal 1995, 41 (1), 97–109. https://doi.org/10.1002/aic.690410110

Cite this article as :

Rutik Hemanbhai Majethiya, Dr. Ashish Unnarkat, Mr. Yogendra Dave, "Process Hazard Analysis of Process Industries", International Journal of Scientific Research in Science and Technology (IJSRST), Online ISSN : 2395-602X, Print ISSN : 2395-6011, Volume 9 Issue 5, pp. 676-691, September-October 2022.
Journal URL : https://ijsrst.com/IJSRST52411153